Developing Seed Zones

The most reliable seed transfer guidelines would be developed after finishing long-term field tests of trees grown from seed collected in many populations from across a geographic region and planted across a range of environmental conditions. However, determining whether trees are adapted to a site takes a long time, sometimes more than 50 years (Roy Silen, personal communication, March 1995). Another valuable approach, when results from long-term tests are not available, is to map genetic patterns of geographic variation with a seedling study. The theory behind this method is that the larger the genetic difference between two populations, the larger the adaptive difference between them, and the greater the risk of moving seed between them. The assumptions behind this technique are that genetic differences between populations are largely adaptive, that the local population is most suited for a particular site, and that a map of genetic variation is also a map of the environment that shaped natural selection. Adaptation to environmental conditions is apparent when genetic and environmental variation are closely correlated; for example, when higher elevation sources set bud earlier. These tests can also identify the fastest growing families; long term tests of Douglas-fir in western Oregon have shown that trees tend to grow at a steady rate and that the fastest growing families can often be determined at an early age. However, this technique must be applied cautiously. A source or family that grows rapidly for a short period of time may not survive for the long term.

Both long-term field tests and seedling studies start by choosing many parent trees from across the area of interest, collecting seed from them, and growing the seedlings in the nursery. For long-term tests, nursery seedlings are then planted at several locations where the site conditions reflect the range of environments for that species in the area under study. Seed transfer recommendations are made after assessing survival, growth, and tree development for many years. The seedling- study approach utilizes the seedlings which are grown in more than one environment while they are still at the nursery. A large number of traits that relate primarily to growth and phenology are measured to determine patterns of genetic variation. Geographic areas or distances within which seed can be transferred without undue risk of maladaptation are estimated from observed genetic patterns. However, one must remember that seedling tests do not evaluate all risks. Seed transfer zones developed from them should be considered provisional until long-term field results become available.

Genetic differences among populations usually develop in response to variation in important environmental factors, especially temperature, length of the growing season, and moisture. A continuous change in these parameters from one location to another is known as an environmental gradient and a continuous genetic change along this gradient is known as a cline. Ideally, seed zones would be determined by knowing how these important environmental factors change across the landscape and how the species adapt to these changes. However, little is known about temperature and moisture in most forested parts of the West. This is because most climatic information is gathered for agricultural use from weather stations in the lowlands. Few weather stations exist in mountainous forested regions. Therefore, genetic researchers in the western United States have based tree seed zones and seed transfer rules on surrogates for climatic data that are easier to measure. Some of the most commonly used variables are elevation, latitude, longitude, distance from the coast, and distance from the crest of major mountain ranges. Because the zones that are developed from these analyses are based on the relationship between genetic variation and geographic factors rather than climatic factors, they may not be appropriate if there are large changes in climate. Other surrogates for climate which have been tested, but have usually turned out to be less useful, are slope, aspect, habitat type and soil type.

Since geographic variation and genetic variation are usually continuous variables, mathematical models that describe the relationships between them can be developed. These models usually provide the best estimate of risk when transferring seed. The larger the predicted genetic difference between populations from the seed source and populations from the planting location, the greater the risk of seed transfer. These models generally use the distance of the transfer, for example, in degrees latitude or longitude and feet of elevation, to estimate the risk of maladaptation. Unfortunately, many of these models are quite complex and people are often reluctant to use them. In addition, the research needed to develop these models has not been published for most of Washington. For these reasons, the recommendations that follow are based on seed zones instead of mathematical models.

Mathematical models have been developed for parts of Idaho and Montana for some species. In some cases, these models may apply to the northeast corner of Washington. These models are available on an electronic web page maintained by the Idaho Panhandle National Forests at their Coeur d'Alene nursery (Mary Mahalovich, personal communication, August 2000). Landowners in the northeast corner of the State may want to consider this source of additional information.

In Washington, there has been very little research specifically designed to determine the limits of seed movement. However, this work has been done in areas that surround Washington, including Oregon, Idaho, and British Columbia. Generalizations derived from studies in these nearby areas can often be applied in Washington. Indications of how far seed can be moved may be obtained from other types of studies as well; for example, ones that are designed to identify the fastest growing trees. Some excellent information can also be obtained from studies of seed collected in Washington and tested in Europe. Some genetic studies are now in progress in Washington and additional ones are planned. As the results of these studies become available, the recommendations in this document may need to be modified.

The areas included in the seed transfer zones in this document are based on the maps of species distributions developed by Elbert Little (1971). In some cases, Little's maps do not reflect current knowledge of the species distribution. In these cases, the seed transfer zone maps have been modified as suggested by local experts.

Since the environmental gradients and genetic clines are continuous, in many cases the borders between seed zones are somewhat arbitrary. If land ownership is split by a seed zone boundary, boundary adjustments may be possible to facilitate land management. This is especially true if a tree seed zone of a given size is moved north or south.